FOOTSTEP LOCALIZATING BY ACOUSTIC SIGNALS

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ABSTRACT

This contribution describes a system able to detect footstep locations. through acoustic information retrieved from a wireless sensor network with small and cheap microphone arrays. Results of this system show that a best median errors of 31cm is achievable.
Keywords: footstep location estimation, gait analysis

1. INTRODUCTION

It is shown that the gait of a person is related with his/her health condition [1]. This work focuses on detecting footstep positions by acoustic information, acquired from cheap electret microphones. Acoustic sensing has the advantage that it is passive and contactless. Here the setup of a wireless acoustic sensor network (WASN) has been chosen differing from work using only one microphone array [2]. Such WASNs contain multiple so called nodes each holding at least one microphone, having multiple advantages over other setups [3].

2. SYSTEM DESCRIPTION

The proposed system consists out of 4 nodes with 3 electret microphones with an inter-sensor distance of 6.8 cm, placed at ground level. A visualization of all tasks to be performed along with examples of intermediate results is shown in Figure 1.

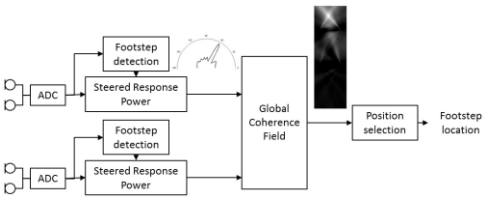

Figure 1: System outline

A first stage detects the presence of a footstep by an energy threshold. In a second stage each node is capable of estimating the sound energy coming from a certain direction by using steered response power [4]. The third stage combines the directional energies of all nodes to a 2D map by global coherence field [5].

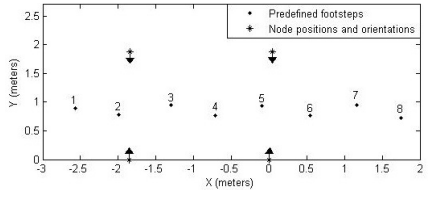

Figure 2: Recording setup

3. DATASET

Two test subjects were asked to walk 8 times on a predefined path containing 8 steps. The nodes and the footstep positions are shown in Figure 2.

4. RESULTS

Figure 3 shows boxplots of the errors for each position. The median of errors range from 31 to 92cm. The figure indicates 2 important effects. Firstly that the errors are smaller for positions enclosed by the nodes. This indicates the importance of a well-chosen setup. Secondly we can notice outliers. This is an important conclusion for the future design of a post processor.

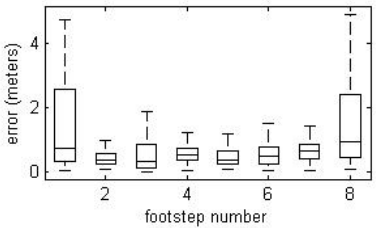

Figure 3: Results

5. CONCLUSIONS

This work focused on estimating footstep locations using acoustic information retrieved from a WASN. A system flowchart was presented with algorithms for each subtask. Experiments on a real life dataset showed that the system is able to detect footsteps with a best median errors of 31cm. But also showed that these results depend on the node setup and that there are outliers, which will be of uttermost importance in designing a post-processing algorithm.

References

[1] J. Verghese, C. Wang, R.B. Lipton, R. Holtzer, X. Xue, Quantitative gait dysfunction and risk of cognitive decline and dementia, Journal of Neurology, Neurosurgery & Psychiatry, vol. 78, pp. 929-935, 2007

[2] M. Shoji, Passive Acoustic Sensing of Walking, Midori-cho, Musashino-shi, Tokyo, Japan, 2011.

[3] A. Bertrand, Applications and trends in wireless acoustic sensor networks: a signal processing perspective, in Proc. of the IEEE Symposium on Communications and Vehicular Technology (SCVT), Ghent, Nov. 2011.

[4] I. Tashev, Sound Capture and Processing, John Wiley and Sons, 2009.

[5] A. Brutti, M. Omologo, P.G. Svaizer, Oriented global coherence field for the estimation of the head orientation in smart rooms equipped with distributed microphone arrays, Eurospeech, Lisboa, 2005.